

**Title of Invention****SOIL PENETRATING ELECTRODE WITH CONICAL TAPER**

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APPLICATION NR: 60/458,896  
CONFIRMATION NR: 9306**Statement Regarding Federally Sponsored Research or Development**

This invention was not made under any federally sponsored research and development whatsoever.

**FIELD OF THE INVENTION**

The invention relates to the field of soil mechanics where measurement of soil percent compaction and moisture content are required for road beds and construction foundations. More particularly, the invention relates to the measurement of soil electrical resistance and soil electrical capacitance at a radio frequency, wherein an electrode is used to connect the measurement instrumentation to the soil.

**BACKGROUND OF THE INVENTION**

There have been many applications wherein soil electrical properties have been measured to determine geological characteristics of soils and earth structures in situ. Generally the electrode structure has not been identified in the description of these inventions. U.S. Patent No. 5,450,012, issued to Champagne, et.al. on Sept. 12, 1995, describes a Soil Electrode design that is claimed to be useful for determination the resistance of a volume of soil. Other prior art includes U.S. Patent No. 2,611,643 of R. V. Higgins, granted on Sep. 23, 1952 that describes an automatic sprinkling device which includes two electrodes inserted into soil. U.S. Patent No. 3,905,551 of Charles Ayme de la Lachevreliere, granted on Sept. 17, 1975 describes a soil sprinkling device

employing two electrodes, one lying in the upper sprinkled layer, and the other lying within the permanently moist layer at sufficient depth.

## **SUMMARY OF THE INVENTION**

An object of this invention is to be able to make a repeatable and stable electrical contact with soil for measurement of its electrical properties.

Another object of this invention is to be able to control the area of electrical contact with soil for measurement of its electrical properties.

Yet another object of this invention is to be able to make it easy for the user to obtain repeatable and stable contact with soil for measurement of its electrical properties.

The purpose of the Soil Penetrating Electrode with Conical Taper is to provide repeatable and stable electrical contact with soil for the purpose of measuring the electrical characteristics of the soil at a radio frequency. When used with the Electrical Density Gauge, the percent compaction and moisture content of the soil can be determined in situ from the measured electrical properties.

The Soil Penetrating Electrode with Conical Taper is made from metal that is hard enough to be hammered into the earth or soil, yet ductile enough to prevent shattering when hit. Typically, the composition of oil hardening drill rod is ideal for this application. The dimension of the Electrode is dependent upon the application requirements, and this description is intended to show an electrode suited to a typical application.

A conical shape has been designed for a soil penetrating electrode that continually compacts the soil around the electrode as it is driven in. This

continual compaction achieves excellent contact all around the conical shape, and provides excellent control of the area of contact with the soil. Further to controlling the contact area, a shoulder is machined at the end of the conical taper that is undercut. When the conical electrode is driven in the soil to the level where the shoulder is level with the soil surface, a repeatable area of the electrode is in contact with the soil.

If the electrode is driven farther into the soil, such that the shoulder is below the surface of the soil, the soil crumbs that may fall back in the cavity surrounding the undercut part of the electrode shaft make a comparatively poor contact with the electrode. Consequently, a negligible change results in the functional contact area of the electrode with the soil. Thus, the conical electrode shape that is the subject of this invention assures positive soil contact and substantially constant contact area without the requirement for highly accurate placement with respect to the soil surface.

For this application, a 6 in. long Electrode is described, and detailed in Fig. 1. The length of the soil electrical contacting area (2) of the Electrode is three (3) inches. For best accuracy it is desirable that the total contact area be constant from measurement to measurement. It is also desirable that the Electrode be in intimate and tight electrical contact with the compacted soil. It is the object of this invention to solve the problem of constant electrical contact area and also to solve the problem of intimate electrical contact with the soil.

The contact area of the Electrode is machined to be a conical section that has a diameter of  $\frac{3}{16}$  in. at the penetrating end (1), and a diameter of  $\frac{1}{2}$  in at the top of the contact area (3). The conical taper is such that the spacing between the  $\frac{3}{16}$  in. dia. location and the  $\frac{1}{2}$  in. dia. location is 3 inches. As the Electrode is driven into the soil, the diameter of the hole continues to increase everywhere along its length, thus assuring intimate electrical contact.

At the ½ in. dia. location, a 1/16 in. shoulder (3) is machined, which reduces the diameter of the Electrode to 3/8 in. This shoulder provides a visual reference to assure that the Electrode is driven into the earth or soil, the full design distance of 3 in. From that point a 3/8 in. dia. cylindrical section (4) is machined for the remainder of the total 6 in. length of the Electrode. This cylindrical section provides a place to manually grip the Electrode while it is being driven into the soil, as well as a place to which electrical connectors can be affixed.

The cylindrical section also provides an under-cut area, which no longer has intimate electrical contact with the soil or earth. Even if the Electrode is driven slightly deeper than the 3 in. design depth, the intimate electrical contact area will still be only 3 in. long. And, should any crumbs of earth fall into the undercut area, the relative electrical contact with the soil will be very small when compared with the tight electrical contacting area of the conical section

Lastly, a hole (5) is drilled transversely through the top area of the cylindrical section of the Electrode through which a rod or nail can be inserted to permit the electrode to be twisted as it is pulled from the earth or soil after use. This feature permits easy withdrawal of the Electrode, when driven into highly compacted soils.

## **BRIEF DISCRIPTION OF THE DRAWING**

FIGURE 1 is a side view drawing of the Soil Penetrating Electrode with Conical Taper.

## **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Figure 1 shows a drawing of the conductive metallic conical soil penetrating electrode that is the subject of this invention. The point (1) of the

electrode has been blunted purposely to prevent distortion of the metal when a rock is struck while placing the electrode.

The conical tapered area (2) of the electrode has a taper that starts at 3/16 in. diameter and increases to 1/2 in. diameter over a 3 in. length. This small angle taper assures ease of driving the electrode into compacted soil, yet serves to compress the soil around the electrode over the whole length of soil contact.

The undercut shoulder of the conical electrode (3) is used as a guide for consistent soil penetration. The electrode is at the correct depth when the shoulder is at, or slightly below, the surface of the soil.

The undercut is 1/16 in. to allow enough space between the 1/2 in. diameter soil hole caused by the top of the conical part, and the 3/8 in. diameter electrode shaft (4). The 3/8 in. shaft is typically 3 in. long.

A hole in the top of the electrode shaft (5) is provided for inserting a nail or other metal rod to allow the electrode to be rotated as it is withdrawn from the soil. In highly compacted and dry soils, it is difficult to remove the conical electrode because of the high compaction pressures around the wall of the conical part. By twisting and pulling at the same time, this compaction pressure can be released easily, allowing withdrawal by hand.

The conductive metallic soil penetrating electrode can be made from steel, stainless steel, bronze, or other metal with suitable electrical conductance for the application.

The above description of the conical electrode includes typical dimensions, which may change according to the soil type and application of this new electrode shape.